

Optimal Location of DG Units with Exact Size for the Improvement of Voltage Stability Using SLPSO

S. Mani Arasi¹, R. M. Sasiraja²

¹PG Scholar, Department of Electrical and Electronics Engineering, Anna University Regional Office, Madurai, Tamil nadu, India

²Faculty, Department of Electrical and Electronics Engineering, Anna University Regional Office, Madurai, Tamil nadu, India

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ABSTRACT

The congestion in transmission lines which leads to instability in the power system operation. Distributed generation is used to minimize the power losses and to improve the system stability. Improper DG placement may increase system losses, network capital and operating costs. To find the size and location of distributed generation, in order to minimize line losses of power system. This paper uses the Maximum Power Stability Index (MPSI) which is derived from the maximum power transfer theorem. The maximum power delivered by system is when ratio of load power to Thevenin's network power delivered is equal to one. The MPSI is employed as an objective to determine the optimal DG locations. Social Learning Particle Swarm Optimization (SLPSO) technique is applied to find the optimal size of DG units with the objective of reducing losses. In the proposed approach, IEEE 30 bus test system is used.

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Corresponding Author:

Mani Arasi .S

Department of Electrical and Electronics Engineering,
Anna University Regional Office,
Madurai, India

Email Id: ssmaniarasi@gmail.com

I. INTRODUCTION

Electrical energy is vital in every aspect of day-to-day life. Keen interest is taken on all possible sources of energy from which it can be generated and led to the encouragement of generating electrical power using renewable energy resources such as solar, tidal waves and wind energy. Due to the increasing interest on renewable resource in recent times, the studies on integration of distributed generation to the power grid have rapidly increased. The distributed generations (DG) sources are added to the network mainly to reduce the power losses by supplying a net amount of power. The optimum DG location has the impact of the power losses value, voltage stability as well as the voltage profiles of the network.

Distributed generation is an electric power source connected directly to the distribution network or on the customer side. The purpose of distributed generation is to provide a source of active electric power.

II. LITERATURE SURVEY

Some of the important definitions of DGs and their operational constraints are given [1]. The analytical methods used to regulate the optimal location of DG in radial networked systems to minimize the power loss of the system [2].

The cost evaluation, benefits for customers and utility such as reliability enhancement, customer interruption cost reduction and peak load cost reduction has not been included for solving the location and sizing problem [3],[4]. GA-Fuzzy based optimal placement of DG considering multi-objective functions including system losses, system loading as well as the profit for Distribution Companies [5]. The costs of DG placement are sensitive to the DG types, manufacturers, DG techniques, utility policies, government policies and utilization rate etc. [6].

Distributed Generator placement and sizing for distribution systems based on an index which is developed by considering stable node voltages referred as power stability index (PSI) and voltage instability of the system [7],[8]. The new regulations and policy, or to reduce their operational costs and maximize their profits are explained [9]. System operating beyond those limits can lead to the absence of generator synchronism, transmission outages or might result in partial or total system voltage collapse and its protection [10]. Indices are developed to avoid the system blackouts. The dynamic voltage collapse prevention indices are power collapse prevention index, Line index, power margin [11]. New Voltage Stability Index (VSI) is considering within proper voltage range [12].

Artificial bee colony algorithm (ABC) is used to determine the optimal DG-unit size and location by loss sensitivity index (LSI) in order to improve the voltage stability in radial distribution system [13]. Combination of

particle swarm optimization and Newton-Raphson load flow method to determine the location and size of the DG for the minimization total power losses and improving the voltage profiles of the system and tested on IEEE 69-bus distribution test system [14]. Particle Swarm Optimization algorithm (PSO) is presented as the optimization technique for the allocation and sizing of DG in distribution networks for THD and loss reduction [15]. The non-optimal DG location and size based on Maximum Power Stability Index using PSO [16].

III. LOAD FLOW ANALYSIS

The most popular method for solving the non-linear system of equation is known as Newton Raphson Method. This method begins with initial estimation of all unknown variables. The main advantage of Newton Raphson method is the superior convergence because of quadratic convergence usually employed for large sized system. It is more accurate and smaller number of iterations than Gauss-Seidel method. The number of iterations is not dependent on the system size. The method is insensitive to factors like slack bus selection, regulating transformers and presence of series capacitors. It is comparatively faster and more reliable.

IV. COMPUTATION OF MAXIMUM POWER STABILITY INDEX

If there is a load growth or increase in the load, causes the system voltage to fall below its limits. So, it is very important to maintain the dropping voltage level as original. Therefore, solution for this is to find the proper location of DG units. In order to discover the opt location for placing the DG units, a new index called Maximum Power Stability Index is used in this study. MPSI is calculated using the formula,

$$MPSI = \frac{4(V_L)^2}{\left[\sum_{i=1}^n \left(\frac{V_i}{V_{ij}} \right)^2 \right]} \quad (1)$$

Maximization of MPSI index for the optimal location with the help of voltage profile as,

$$G = \max MPSI \quad (2)$$

The optimal location of DG in the distribution system is identified as the bus, which has the maximum value of MPSI.

V. PROBLEM FORMULATION

It is very important that finding the optimal DG location and size to maintain the voltage profile and to minimize the active power losses.

A. Objective function

Minimization of real power losses are used as objective. The real power losses in the system is given by Eq. (3),

$$f = \min \sum_{x=1}^n P_{loss}(x) \quad (3)$$

B. System Constraints

The exact or nearer output can be obtained by considering the influencing parameters, as constraints. Then, the constraints are

Bus voltage and real power constraints:

$$V_i^{\min} \leq V_i \leq V_i^{\max} \quad (4)$$

$$P_{DG}^{\min} \leq P_{DG} \leq P_{DG}^{\max} \quad (5)$$

Power balance constraint:

$$\sum_i^{ng} P_{gi} = \sum_i^{nl} P_{Di} + P_{loss} \quad (6)$$

VI. SOCIAL LEARNING PARTICLE SWARM OPTIMIZATION (SLPSO)

In 1921, some British birds were first seen to open milk bottles in the small town of Swaythling. In the following 25 years, such observations had been continually reported from numerous other sites spreading all over the Great Britain and even some other areas in the European continent. This is the first evidence of social learning, where the birds are believed to learn to open milk bottles by observations and interactions with other birds, instead of learning by themselves. Among these mechanisms, the most interesting social learning mechanism is imitation, which is considered to be distinctive from other social learning mechanisms, because imitation, which operates across a whole community, could lead to population-level similarities of behavior such as culture or tradition. Such population-level similarities may imply convergence of a dynamic system, thus providing its essential applicability in an evolutionary algorithm.

In the following, few new learning mechanisms inspired from social learning to replace the updating rules in the canonical PSO. Without loss of generality, we consider the following minimization problem:

$$\min f = f(x) \quad (7)$$

$$s.t. X \in x$$

where $x \in R^n$ is the feasible solution set, n denotes the dimensionality of the search space, i.e., the number of decision variables, which are the behaviors to learn in the context of social learning. The first parameter to be determined is the swarm size m . We recommend that the swarm size m be determined as a function of the search dimensionality in the following form:

$$m = M + [n/10] \quad (8)$$

where M is the base swarm size for the SL-PSO to work properly. The Fig.1 is the main components of SLPSO algorithm.

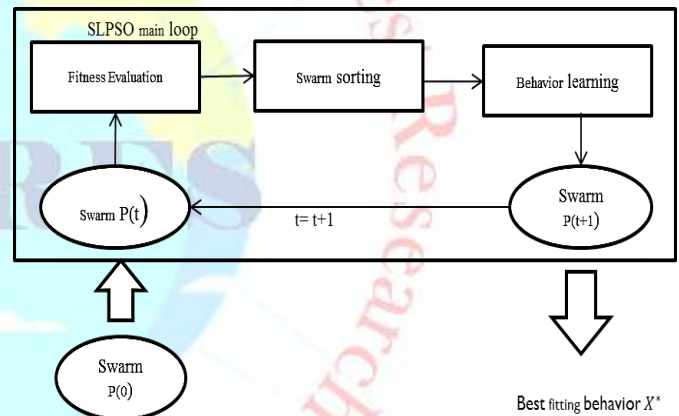


Fig.1. Main components of SLPSO

VII. RESULTS AND DISCUSSION

The obtained results are tested in IEEE 30 bus system. The single line diagram of the IEEE 30 bus system is shown in Fig.2. The IEEE 30 bus system has 6 generators, 24 load buses and 41 branches. The coding is developed by the Matlab/Matpower [18] version 4.1. Matpower is a package of Matlab M-files for solving power flow and optimal power flow problems. Matpower is designed to give the best performance possible while keeping the code simple to understand and easy to modify. The detail of IEEE 30 bus system is obtained from the Matpower.

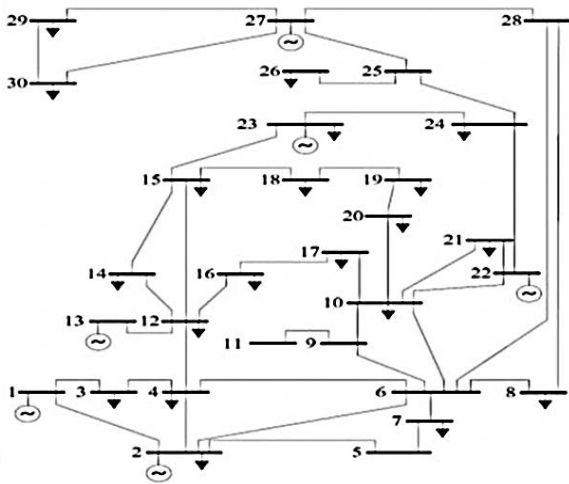


Fig.2. single line diagram of IEEE 30 bus system

The Table 1 gives the top two MSPSI index which is identified as the optimal location of DG units for the IEEE 30 bus system.

Table 1. MSPSI values and potential places for DG placement for IEEE 30 bus system

Optimal location based on the index	
Location	MPSI Index
7	0.9783
19	0.9727

The Fig.3 gives the voltage profile improvement of the Base case, One DG and Two DG placement for IEEE 30 bus system. From Fig.3, the curve for Two DG locations gives the better voltage profile improvement than the other two cases.

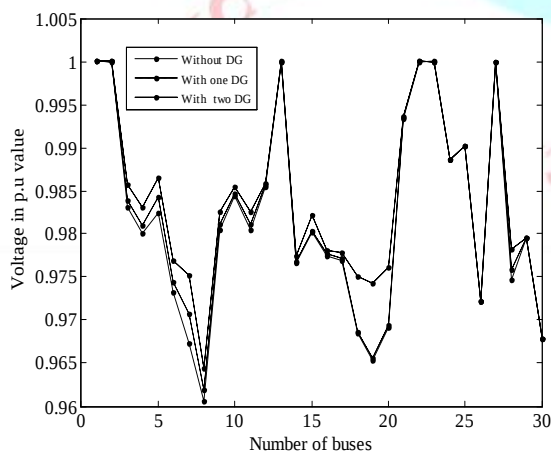


Fig.3. Voltage profile of Base case vs. One DG, Two DG placement

The fitness function for IEEE 30 bus system is shown in Fig.4 the fitness value of IEEE 30 bus system optimizes at the initial stage itself. The fitness value of IEEE 30 bus system is 1.765 MW. Thus, nearly 28 %

loss reduction when compared with the base case results.

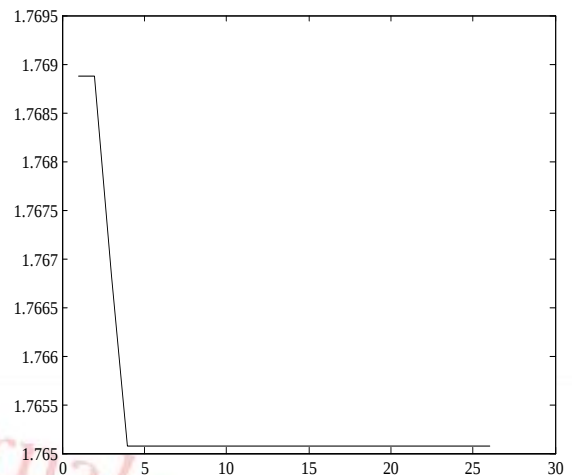


Fig.4. Fitness curve of two DGs

VIII. CONCLUSION

The optimal location and sizing of DG units in IEEE 30 bus system has been established in this paper. The improper location and incorrect size of DG units are creating some serious problems like fault current increase, power quality disturbances, voltage instability issues and upset of relay coordination in existing protection schemes. Therefore, in this paper, the relevant locations of DGs have been determined on the basis of Maximum Power Stability Index which is a good indicator in pointing out the optimal locations of DGs. The problem framed in this attempt is formulated as an optimization problem using Social Learning Particle Swarm Optimization with an objective of minimizing real power losses.

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Author Profiles



S.MANI ARASI received B.E. degree in Electrical and Electronics Engineering from, Sethu Institute of Technology, Pulloor, India in 2013 and currently she is pursuing M.E. degree in Power Systems Engineering from Anna University Regional Office Madurai, India. Her research interest includes Distributed Generations, Renewable Energy Sources, and Soft Computing Techniques applied to Power Systems.



R.M. SASIRAJA obtained B.E. degree in Electrical and Electronics Engineering in 1996 from Madurai Kamaraj University and M.E. in Power Systems Engineering from Anna University Chennai in 2007. Currently, he is working as a Faculty in the Department of Electrical and Electronics Engineering of Anna University, Regional Office, Madurai. He is pursuing Ph.D. in the area of Distributed Power Generation. His area of interest includes Distributed Generation, Smart Grid, Soft Computing Techniques applied to Power Systems, Energy Audit, and Conservation in Industries. He is life member of Institution of Engineers, Kolkata.